To Inspire, Engage, & Educate Today’s Youth Through Technology – Enhanced Space Science Teaching Materials

http://alienrescue.edb.utexas.edu/

Project dates: Sept. 1, 2015 – Aug. 31, 2017

Min Liu*, Ed.D.
http://www.edb.utexas.edu/minliu/

The University of Texas at Austin
Department of Curriculum & Instruction
College of Education
1 University Station D5700
Austin, Texas 78712-0379

Mliu@austin.utexas.edu
512-232-6248

Proposal submitted on May 8, 2015

*The PI is Asian American, female, and physically disabled.
Abstract

An important objective of the educators is to prepare and ensure students to succeed in the 21st century knowledge society. The NASA Education Framework “pyramid” outlines the objective of attracting and retaining the next generation of explorers and innovators by inspiring, engaging, educating, and employing our students. To achieve this goal, it is necessary to enlarge and sustain the science, technology, engineering, and mathematics (STEM) pipeline. To educate students, we must prepare teachers with effective pedagogy and provide them with quality teaching materials. Digital technology should be an especially effective means to motivate today’s youth growing up with technologies, and create opportunities to support deep learning.

This proposal seeks funding to create teacher professional development materials, delivered online, focusing on student-centered and problem-based learning (PBL) pedagogy on the topic of space science to middle school teachers nationwide. The training materials will be based upon an innovative middle school program called Alien Rescue and its PBL approach while incorporating NASA materials. Alien Rescue is an award-winning, 3D immersive space science curriculum developed at UT-Austin. It aims at developing problem-solving, critical thinking, and collaboration skills in middle school students and help them excel in a digitally-driven world. Alien Rescue has been used by 16 middle schools in Central Texas as well as schools in 29 other states and four countries, with a diverse ethnic base. Each year approximately over 6000 students will be impacted. Since not all teachers are comfortable and knowledgeable with this student-centered and problem-based learning (PBL) pedagogy, professional development is necessary. We propose to create training materials to be delivered online using multimedia technologies to reach a broad audience. We also propose to create a website to increase public’s appreciation (i.e. parents and community) for NASA sponsored research and develop relevant math content to connect math concepts to science content already in the program. This project supports TSGC’s main objective of enhancing understanding and appreciation of the benefits of space exploration and space based research.

This proposal will meet all FIVE TSGC goals, as well as align well with NASA 2015 STEM Engagement and Educator PD LOB, because 1) it seeks to increase the participation of underrepresented population in STEM by providing an experiential learning; 2) the team are experts in STEM from the College of Education at UT; and 3) it aims to provide PD training to teachers at middle school level. Importantly, offering online teacher training and using a proven successful technology program to teach space science reflects well the NASA Educator Professional Development Goal to increase STEM literacy of middle school students.

PI has successfully implemented past projects funded by different funding agencies, including ones funded by EPO. She has over 20 years of teaching experience, 15 years in delivering professional development training to K-12 teachers and higher education faculty; as well as designing and developing award-winning technology-enabled programs. The team is already in place and has been working on the development of the project. All these will ensure the success of this project.
PROJECT DESCRIPTION

What is Alien Rescue:
https://vimeo.com/87208314

What teachers and students say:
https://www.youtube.com/watch?v=XK_hJkOFiEt&t=90

Goals of the Project

This proposal seeks funding to create online teacher professional development materials focusing on student-centered and problem-based learning (PBL) pedagogy on the topic of space science to middle school teachers. The training materials will be based upon an innovative space science curriculum called Alien Rescue.

Alien Rescue is an Award-winning 3D immersive multimedia learning environment for middle school space science. The goals of Alien Rescue are to engage middle school students in using knowledge of space science and tools and procedures scientists use to solve a complex problem. It supports collaborative processes of scientific inquiry and facilitates the generation of scientific knowledge. It is a fifteen 45-minutes curriculum unit that is aligned with TEKS as well as national science standards. The story goes like this: A group of six alien species, each with unique characteristics, have traveled to Earth because their home planets have been destroyed. Students take on the role of scientists who are tasked with the mission of finding a new home for each alien species. To accomplish this goal, students must engage in a variety of problem-solving and critical thinking activities. They must also discover some of the critical scientific characteristics of the planets and moons in our solar system. Through these inquiry-based activities, students engage in problem-solving, self-directed learning, and peer collaboration.

Gary Popiolekowski, a teacher at Chartiers-Houston Jr./SR. High School, PA recently sent this comment after using Alien Rescue with his students: “Alien Rescue (AR) was a fantastic activity. I've been involved with problem based learning since '95 and this is terrific way to integrate 21st century technology and skills.“ Another teacher from MD, Shari Connor, stated, “As a teacher, I loved Alien Rescue. I felt that the program not only taught the kids about our solar system, it also forced them to engage in critical thinking skills and to read and learn about unfamiliar material in a very kid friendly and visual format. The children had to use problem solving skills, data taking and keeping skills, inference, they had to draw conclusions and find a best fit solution. I also had very few students who weren't excited about using the program. Thanks for a great teaching tool.”
In 2012, *Alien Rescue* received the **Immersive Learning Award** for its quality and in 2013 it **received the Outstanding Practice Award** for its design model in the national competitions sponsored by major national IT profession organizations such as AECT. Currently, the program is being used by 16 middle schools in Central Texas with a diverse ethnic base. In addition, schools in **29 states** (AZ, CA, CO, CT, FL, GA, HI, IA, IL, IN, KS, MA, MD, MI, MN, MO, MS, NC, NM, NJ, NY, OH, OR, PA, SC, TN, UT, WA, WI) and **four countries** (Australia, Canada, China, S. Korea) have used and are using Alien Rescue. With proper instructional modification by the teachers, the program has been used by students 5th through 10th grades and with various ability levels. Teachers and students’ comments are provided in “Additional Materials” section.

Because this program focuses on student-centered and problem-based learning pedagogy, not all teachers are familiar with or comfortable with this pedagogical approach. We seek funding to provide professional development (PD) online using this award-winning space science program as an example. We propose to accomplish the following activities:

1. Create online professional development materials using multimedia technologies for teachers nationwide; The materials will cover the following:
   - Problem-based learning as a student-centered pedagogy,
   - Techniques to facilitate teaching and student learning,
   - Relevant NASA supported materials for teaching,
   - Strategies and techniques to develop related science and math concepts, and problem-solving skills;
   - Best practices of what works in using technology-enabled tools;
   - Lesson plans for using *Alien Rescue* as a teaching and learning tool.

2. Create a website with activities and resources using NASA materials for parents and community at large to increase public awareness of NASA space exploration research;

3. Develop relevant math content to connect math concepts to science content already existing in the program, specifically relating probe design and probe launch. Appropriate math concepts to be developed and integrated into the program include:
   - Fraction Decimal Conversion
   - Add/Subtract Fractions (mixed numbers and improper fractions)
   - Graph Interpretation
   - Numeric Reasoning with negative integers
   - Percentages
   - Unit Conversion
Roles & Responsibilities

<table>
<thead>
<tr>
<th>Who</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI – Dr. Min Liu, College of Education</td>
<td>• supervise the design and implementation of the project</td>
</tr>
<tr>
<td></td>
<td>• coordinate all efforts</td>
</tr>
<tr>
<td></td>
<td>• recruit and work with a core group of five teachers in developing</td>
</tr>
<tr>
<td></td>
<td>the PD and math content</td>
</tr>
<tr>
<td></td>
<td>• create teacher training materials</td>
</tr>
<tr>
<td></td>
<td>• support classroom pilot-testing</td>
</tr>
<tr>
<td>Jina Kang (Ph.D. student in Learning Technologies with BS and MS in</td>
<td>• check accuracy in content materials</td>
</tr>
<tr>
<td>astronomy)</td>
<td>• create materials for online delivery</td>
</tr>
<tr>
<td></td>
<td>• support classroom pilot-testing</td>
</tr>
<tr>
<td>Jason Harron (Ph.D. student in Learning Technologies and a former</td>
<td>• create math content</td>
</tr>
<tr>
<td>math middle school teacher)</td>
<td>• create materials for online delivery</td>
</tr>
<tr>
<td></td>
<td>• support classroom pilot-testing</td>
</tr>
<tr>
<td>The Center for STEM Education in COE.</td>
<td>The team will collaborate with the STEM center to reach schools in</td>
</tr>
<tr>
<td></td>
<td>rural areas</td>
</tr>
<tr>
<td>School Partners in Leander ISD &amp; Round Rock ISD</td>
<td>Five of the teachers at the 16 Central Texas schools we have been</td>
</tr>
<tr>
<td></td>
<td>collaborating with in the past five years will be selected to help</td>
</tr>
<tr>
<td></td>
<td>test PD content and implement Alien Rescue in their classrooms and</td>
</tr>
<tr>
<td></td>
<td>provide feedback.</td>
</tr>
</tbody>
</table>

How the Project Addresses Five TSGC Goals

Goal 1. Assist K-12 teachers in exciting their students to learn math and science through space based activities.

Alien Rescue (AR) using a multimedia-enriched approach to teach space science offers a new and innovative way of teaching science and engaging today’s digital natives. Feedback from teachers who have used AR has shown the excitement from their students:

“I have never seen middle school students so engaged in reading and using data as when they were ‘playing’ Alien Rescue. When we were finished they asked if they could do it again because it was so much fun!”
“My students have really enjoyed using Alien Rescue. It was a wonderful tool to integrate science in a fun, challenging, and innovative way. Alien Rescue embraces the idea of teacher acting as facilitator as opposed to teaching. Alien Rescue provides the circumstance that definitely keeps the students engaged while the teacher facilitates the learning environment.”

The activities proposed will provide necessary support to assist teachers in using the program and allow teachers to have digital resources and well-designed teaching activities to excite students to learn math and science through space curriculum as presented via Alien Rescue.

**Goal 2.** Increase K-12 educator knowledge in space related fields.

Science is a dynamic discipline and new discovery is made constantly. Alien Rescue includes a large amount of information, via audio, video, text, animation, and 3D images, on the solar system, and scientific instruments used by scientists to study it. Science content is being updated frequently by experts from STEM at the university and shared with the teachers. Using a Web 2.0 tool, a wiki-based teacher’s manual (http://www.edb.utexas.edu/minliu/alienrescue/) has been created to deliver materials just-in-time to teachers. This manual includes 15-day lesson plans, space concepts, NASA materials, science standards, and various assessment instruments developed at the College of Education for sharing with teachers.

The proposed teacher training materials on PBL pedagogy should enhance teachers’ awareness of using PBL to teach space related concepts.

**Goal 3.** Increase K-12 students knowledge in math and science through space related activities.

Alien Rescue has incorporated various motivational elements via multimedia to address students with different learning needs and styles. Numerous research studies with Alien Rescue have indicated that students’ science knowledge significantly increased and they retained much of what they have learned in formal classrooms (Liu et al. 2009; 2011; 2013; 2014). We also reached out to students in an after school program (Boy’s and Girl’s Club) for them to use Alien Rescue (Smith, 2008). Research has shown students’ learning and motivation have significantly increased from pre-test to post-test with an average of a 30-points gain score (Liu et al., 2011, 2014; Kimmons et al, 2012) and female students had higher gain scores in two studies (See http://alienrescue.edb.utexas.edu/research.php for references).

In this proposal, we seek to develop related **math content to be integrated into the science materials.** This will further increase students’ knowledge in math and science through using this space science environment.

**Goal 4.** Increase the public’s appreciation for the direct and indirect benefits of NASA sponsored research.
Students are excited about *Alien Rescue* because they are charged to solve the problem like NASA scientists. As shown in our implementation, one of the favorite activities students like is to launch probes and study the data returned by probes. Such learning activities provide an authentic learning environment to link what students are learning in the classroom to what scientists do in the real world. In addition, much of the information in *Alien Rescue* (e.g. information in the mission database, images of solar system) was taken from the NASA website. Students are asked to research in the mission database about the past missions launched by NASA. The problem-solving approach has a direct reference to how scientists at NASA work.

This proposal seeks to make connections to NASA research more explicitly and create a website with activities and resources using NASA materials for parents and community at large to further increase public awareness of NASA space exploration research.

**Goal 5.** Direct programs to areas of the state that have the few space related resources.

PI plans to seek and reach out actively to schools that have higher numbers of under-represented population such as Title 1 schools in Central Texas, and work closely with *The Center for STEM Education* (http://www.edb.utexas.edu/education/centers/csme/about/) to publicize *Alien Rescue* via its established outreach venues. The Center has a history of providing effective professional development to teachers in science and math and outreach to schools especially in rural and southern border areas of Texas. Through collaborating with the Center, we will access to its network of schools in rural areas to recruit new teachers from areas that lack space resources to use *Alien Rescue*. The proposed PD to be delivered online will ensure to reach all teachers interested.

Another important aspect of this project is that it will involve people from under-represented populations: The PI represents minority and female population and is physically disabled. We also have worked with such alternative places as The Disciplinary Alternative Education Program for Round Rock ISD in using *Alien Rescue*. We will continue to reach out to all middle schools that are interested in it.

**Evaluation plan**

Research is an integral part of this project. A total of 24 research studies have been published and over 30 presentations have been made at national/international conferences (see http://alienrescue.edb.utexas.edu/research.php). Both quantitative and qualitative methods have been used to assess the effectiveness of the program. Evaluation will include well-established instruments:

1. A 24-item science knowledge test with its Cronbach’s alpha of .87, will be given before and after implementation of *Alien Rescue*.

2. To assess students’ problem-solving skills, students’ justification on how well students solve the problem and their rationale will be evaluated using an 8-point rubric.
3. Students’ motivation toward learning will be assessed using a well-established motivation instrument, *Intrinsic Motivation Inventory* (IMI), and their attitude toward learning environment will be addressed using a previously used five-question Likert-scale survey with a Cronbach’s alpha reliability index of .91.

4. To examine teachers’ perspectives and approaches of using PBL like *Alien Rescue*, interviews and classroom observations will be conducted. 25 questions have been developed addressing teachers’ and students’ use (Liu et al, 2012).

**Dissemination plan**

Multiple venues already exist for wide dissemination:

Because the PD is designed for online delivery, free of charge, it will reach any teachers nationwide and worldwide, interested in using the training materials and the program.

*Alien Rescue* website (http://alienrescue.edb.utexas.edu) serves as an important channel for disseminating the program. It shows up on top of Google search so teachers looking for innovative PBL materials will easily find it. In the past three years, we have received about 250 requests worldwide to use the program.

A YouTube video channel and a Facebook page will be set up to promote the program.

Research about *Alien Rescue* and classroom implementation has been and will continue to be shared at national and international conferences such as *ISTE Conference* and *World Conference on Educational Multimedia and Hypermedia*, as well as in refereed journals. See publication list: http://alienrescue.edb.utexas.edu/researchers.php Two presentations will be made this June at these national/international conferences:

- Motivating Students to Learn Science Using a Game-Based Learning Approach, to be presented at ISTE Conference 2015, June.

In addition, educational technology textbooks (e.g. Roblyer & Doering, 2009, *Educational Technology for Teaching and Learning 4th ed.*) have featured *Alien Rescue* as an exemplary PBL program. Pre-service teachers at the University of Texas-San Antonio also used the program in their PD training in Spring 2015 and will continue to use it in Fall 2015. All these means will ensure the PD training and the program to reach a very wide audience for successful dissemination.
Projected Impact

**Numerically.** At present, the program is being used by 16 middle schools in Central Texas with a diverse ethnic base. In addition, schools in at least 29 other states and four countries have used and are using it as their science curriculum. Each year, over 6000 students will be impacted. (Assuming, on average, each teacher is responsible for 5 classes with 20 students each class for a total of 100 students).

We propose to offer online PD to any interested teachers for nationwide dissemination. By actively seeking out under-represented populations, we will make the program available to teachers who lack technology resources so more students can benefit from this program.

**Depth.** Research has shown that PBL is an effective pedagogical approach. Using a student-centered approach like PBL through Alien Rescue will transform the way teachers teach in that teachers’ role will be shifted to that of a facilitator, not an instructor. Alien Rescue provides a concrete opportunity for teachers to implement it. Students will have an authentic learning experience enhanced through multimedia technology. They will have opportunities to develop problem-solving skills valuable for their career goals and become more interested in learning science. In a research study (Liu et al, 2012), teachers described how Alien Rescue helped their facilitator role: “Students become the controllers of their learning and I tend to become more of a mentor than a leader. It allows me more time to support less able students while still challenging the more capable” stated by Mrs. Yvette and “It makes learning relevant as they have a reason to acquire the knowledge and then build on it to reach conclusion” commented by Mrs. Lauren. Enabling student-centered learning is a transformative educational experience. The program and the proposed PD will ensure to support students’ deep learning.

Through using Alien Rescue, students have the opportunity to acquire scientific concepts as required by TEKS, information about our solar system, and practice critical thinking skills. Supportive evidence for this can be found in two letters provided by Leander ISD and Round Rock ISD, included here.

**Plan For Sustainability**

Alien Rescue is currently hosted on a server in the College of Education at UT-Austin. After the conclusion of TSGC funding, the PD materials developed for online delivery and the program will continue to be hosted in the College of Education. Therefore, the project will be sustainable for a long time.
Additional Materials

Video: http://alienrescue.edb.utexas.edu/teachers.php

Sample Comments from Teachers Who have used Alien Rescue

From Teachers in Texas

Alien Rescue is an outstanding collaborative platform which challenged my students and kept them engaged and learning even after the mandatory testing was over for the year. The interactive graphics, databases, and discovery learning format provided my students with innumerable hours of higher-order thinking opportunities. The program required them to collaborate with their classmates, plan probe missions, and learn about the needs of alien species. Work with the periodic table of elements and budgeting to stay within their funding limits added additional challenges to stimulate analytical thought. This program is an outstanding addition to my curriculum and I look forward to having my students participate in it again this year.

--Kelly Snyder, Haynes Elementary, Kileen ISD

One of my favorite comments came from a student who is typically disruptive during any kind of group work. She said to me on day two, ‘I am so mad at you! You’re making me like science.’ That was a great comment.

--Jennifer Squires, Hopewell Middle School, TX

When I see 7th and 8th graders in the hall, and I tell them that we are doing Alien Rescue, they say, ‘Oh, I remember doing that. It was fun!"

--Patricia Nixon, Cedar Valley Middle School, TX

I often see many of my students who don’t shine during the year really find their niche using Alien Rescue.

--Sue Hill, Cedar Valley Middle School, TX

From Teachers in Other States & Countries

Alien Rescue (AR) was a fantastic activity. I’ve been involved with problem based learning since ’95 and this is terrific way to include/integrate 21st century technology and skills. AR takes a problem, allows the students to ask questions and research and then propose possible solutions. The interaction and communication amongst the team members was terrific. It was great listening to them discuss/argue as they researched and collected info from their probes. It allowed them to learn about so many topics as they tried to find new homes for the aliens. Thanks so much for allowing me to use this in my class. I look forward to using this again next year!

----Gary Popiolkowski, Chartiers-Houston Jr./SR. High School, PA
They were obviously actively involved in learning. They weren’t passive; they weren’t just sitting there. They were asking questions and trying to answer the questions.

--Steve Rhoades, Wilson Central Junior High School, PA

All the students stayed on task during each session. They were able to discuss possible solutions in a calm and reasonable manner. Their questions to me were very well thought out.

--Lynda Marshall, Merriwa Central School, Australia

What I like about Alien Rescue is that it fits so many different kids. It’s a great program; it can be so challenging and set a high bar, or it can include so many kids that are low level. They are interested in it because it’s sort of like a video game.

--Audrey Case, Skyview School, AZ

As a teacher, I loved Alien Rescue. I felt that the program not only taught the kids about our solar system, it also forced them to engage in critical thinking skills and to read and learn about unfamiliar material in a very kid friendly and visual format. The children had to use problem solving skills, data taking and keeping skills, inference, they had to draw conclusions and find a best fit solution. I only had one pair (out of 13 pairs of students) who got all of the aliens placed the first time around - and I also had very few students who weren’t excited about using the program. Thanks for a great teaching tool.

--Shari Connor, Middle School Science, Holy Cross Elementary, MD

My students have really enjoyed using Alien Rescue. My focus as the technology teacher for our middle school is to integrate grade level math and science standards into the technology curriculum. Alien Rescue was a wonderful tool to integrate science in a fun, challenging, and innovative way. Alien Rescue embraces the idea of teacher acting as facilitator as opposed to teaching. It provides the circumstance that definitely keeps the students engaged while the teacher facilitates the learning environment.

The students had so much fun designing and launching probes, and using the science database, the spectogram, and the periodic tables, they almost forgot it was an educational program! It was a great way for them to learn and they learned a great deal about space. More importantly, I believe this interactive program helped them to retain the information much better than typical classroom work. A few of my students that have had some academic struggles were able to not only do well, but also take on a leadership role within their group.

--Stacy Acker, Columbia Local Schools, Columbia St. OH
What’s different about *Alien Rescue*?

Several features of *Alien Rescue* set it apart from other computer programs designed to be used as part of a science curriculum.

**Age Level:** *Alien Rescue* is targeted toward 6th graders, an age level for which there is little instructionally sound science software available. The instructional strategy used in the program, problem-based learning (PBL), has been shown to be effective, but its use has largely been restricted to mature or gifted learners. The rich variety of cognitive tools offered in *Alien Rescue* provides support for a wide range of students so that they can enjoy the educational benefits of PBL.

**Complex and authentic Problem:** The problems students encounter in their curriculum are typically well-structured, meaning that they contain all the information needed to solve them and have only one correct solution. Real-life problem solving is rarely so straightforward. By dealing with a complex problem where they must identify their own learning needs and discriminate among several viable options, students develop the skills they need to deal with problems they encounter in the real world.

**New Media Cognitive Tools to Support Knowledge Construction:** As students gather information, they need to organize it in ways meaningful to themselves and share that understanding with others. *Alien Rescue* provides a number of cognitive tools that support students in this effort. Rich and timely resources support students’ cognitive processes and make problem-based learning a viable instructional approach, even with large classes.

**Meaningful Learning:** All activities in *Alien Rescue* are grounded in students’ efforts to develop a solution plan to the core problem; therefore students have a purpose for learning. They come to see knowledge as a tool that can be used to solve problems and understand the world. Information and skills learned in this manner are more meaningful to students and more likely to be used in other situations than when this same knowledge is taught through methods that do not provide a purpose for learning.

**Ownership of the Learning Process:** The central problem in *Alien Rescue* is highly motivating to this age level. As students become involved in the storyline, they take on the responsibility of developing a solution plan. They generate their own learning needs and actively seek resources to meet those needs. These self-directed learning skills are an integral part of lifelong learning and are an important educational goal.

**Curriculum Integration:** Solving complex problems in real life requires the use of information and skills drawn from a variety of disciplines. While *Alien Rescue* focuses primarily on space science, students must also use math and reading skills and draw on knowledge from a variety of scientific fields.

**Incorporation of Research into Development:** Unlike many other software programs on the market, the design and development of *Alien Rescue* is guided by current findings in educational research. Research is an essential part of this project. Results of research studies are being integrated into the development and improvement of the program. As a result, the product is sound in theory and effective in practice.
Screen Shots Showing Technology Tools In Alien Rescue

a) Alien database

b) Mission database

c) Solar database

d) Probe design room

e) Space station

f) Concept database
Alignment of *Alien Rescue* with the Texas Essential Knowledge and Skills (TEKS)

*Alien Rescue* was designed to meet the learning goals set out in the National Science Standards and TEKS. The following is a *sample* chart that identifies the features of *Alien Rescue* that address these standards. Complete alignment between National Science Standards and Alien Rescue is available upon request.

<table>
<thead>
<tr>
<th>TEKS 2010</th>
<th>ALIEN RESCUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) The student, for at least <strong>40%</strong> of instructional time, conducts laboratory and field investigations following safety procedures and environmentally appropriate and ethical practices.</td>
<td>(A) demonstrate safe practices during laboratory and field investigations as outlined in the Texas Safety Standards&lt;br&gt;(B) practice appropriate use and conservation of resources, <em>including</em> disposal, reuse, or recycling of materials.</td>
</tr>
<tr>
<td>(2) The student uses <em>scientific inquiry</em> methods during laboratory and field investigations.</td>
<td>(A) plan and implement comparative and descriptive investigations by making observations, asking well-defined questions, and using appropriate equipment and technology;&lt;br&gt;(B) design and implement experimental investigations by making observations, asking well-defined questions, formulating testable hypotheses, and using appropriate equipment and technology;&lt;br&gt;(C) collect and record data using the International System of Units (SI) and qualitative means such as labeled drawings, writing, and graphic organizers;&lt;br&gt;(D) construct tables and graphs, using repeated trials and means, to organize data and identify patterns;&lt;br&gt;(E) analyze data to formulate reasonable explanations, communicate valid conclusions supported by the data, and predict trends.</td>
</tr>
<tr>
<td>(3) The student uses <em>critical thinking</em>.</td>
<td>(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student;&lt;br&gt;(B) use models to represent aspects of the natural world such as a model of Earth's layers;&lt;br&gt;(C) identify advantages and limitations of models such as size, scale, properties, and materials(D) relate the impact of research on scientific thought and society, including the history of science and contributions of scientists as related to the content.</td>
</tr>
</tbody>
</table>